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Aortocoronary bypass grafting in patients without left main stenosis

Relation of risk factors to early and late survival

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SUMMARY Three-hundred and thirty-five patients without left main stenosis or recent acute myocardial infarction underwent isolated aortocoronary bypass grafting during 1974 and 1975. The hospital mortality was 2 per cent and the four-year predicted survival is 94 per cent. Neither the preoperative presence or absence of a progressive or unstable angina pattern, the extent of coronary artery disease, nor the left ventricular ejection fraction predicted postoperative survival. None of the 25 patients whose ejection fraction was 0·30 or less died in the perioperative period, and no late deaths occurred in this subgroup until after 36 months of follow-up, giving a predicted four-year survival rate of 82 per cent. With only one exception, patients in this subgroup were operated on because of angina, which was unstable in three-quarters of them. We believe that this study shows that patients with a severely reduced ejection fraction should not be refused aortocoronary bypass grafting if symptoms of angina are severe and predominate over symptoms of heart failure.

Recent studies have indicated that survival is enhanced in patients with stenosis of the left main coronary artery who undergo aortocoronary bypass grafting.[1-3] Clinical investigators do not agree, however, whether this is also true in patients with coronary artery disease who do not have left main stem stenosis. The current study was undertaken to examine this question in a recent series of patients. Special attention was given to factors believed to imply high risk, including extensive coronary artery disease, poor left ventricular function, and progressive chest pain.

Methods

Three hundred and thirty-five consecutive patients who underwent selective coronary angiography, left ventriculography, and aortocoronary bypass grafting during 1974 and 1975 were studied. Patients who had significant stenosis of the left main coronary artery, those who had suffered an acute myocardial infarction less than one month before operation, and those undergoing resection of a left ventricular aneurysm or valve replacement were not included. Because of the small number of patients whose left ventricular ejection fraction was 0·30 or less, all of the nine consecutive patients who underwent grafting in 1976 and who had a left ventricular ejection fraction of 0·30 or less were also included in the study.

Silhouettes of left ventricular end-systolic and end-diastolic right anterior oblique cine frames were drawn in all patients with abnormal wall motion, and the ejection fraction was calculated by the modified area-length method.[4] The cineangiogram was not available for review in eight patients; in these cases, the left ventricular ejection fraction was estimated as greater than 0·30, 0·31 to 0·50, or greater than 0·50 from the narrative description in the ventriculographic report. Three patients did not undergo left ventriculography.

The location and degree of coronary artery narrowing were determined from angiographic

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reports. The cineangiograms were reviewed if the report was not judged sufficient for purposes of the study. In addition to recording the extent of coronary artery disease in the standard notation of one, two, or three-vessel disease, the coronary circulation was considered as six segments: the left anterior descending beyond its major (largest) diagonal and septal branches, the major diagonal branch, the major septal branch, the left circumflex beyond its major marginal branch, the major marginal branch, and the posterior descending artery (whether this arose from the right coronary artery or the circumflex). Each arteriogram was assigned a score, which has been termed the "jeopardy score",[5] that expresses how many of the six segments are affected directly or indirectly by proximal obstruction. Two points are counted for each segment in jeopardy, giving possible scores of 0 to 12. Stenosis was considered significant when the vessel diameter was reduced to 50 per cent or more. Significant stenoses are not differentiated from complete occlusions in the jeopardy score system; lesions are counted or not on an all-or-none basis.

A dedicated file was constructed at the Duke University Medical Center computerised data bank. The clinical factors of age, sex, history of diabetes mellitus, history of hypertension, and severity of angina, as well as the angiographically determined percentage stenosis of each coronary artery, jeopardy score, and ejection fraction were entered for each patient. *Progressive angina* was defined as an increase in the severity or frequency of angina in the month preceding surgery, *refractory angina* as angina that could not be prevented by maximal medical treatment in hospital. The previous occurrence of pulmonary oedema, diuretic treatment, the presence of a third heart sound, the cardiothoracic ratio, evidence of heart failure on chest films, the indication for surgery, and the left ventricular end-diastolic pressure were recorded for patients with a left ventricular ejection fraction of 0·30 or less. *Heart failure* was defined as recent or remote evidence of heart failure on a chest *x*-ray film or a left ventricular end-diastolic pressure exceeding 25 mmHg at the time of cardiac catheterisation. *Operative death* was defined as death before hospital discharge. Survival status was obtained by telephone contact or chart review. Two patients were lost to follow-up. All other patients were followed for three years and approximately half for four years. Three patients had repeat aortocoronary bypass grafts and were not excluded from follow-up.

Predicted survival rates from the time of operation were calculated by standard lifetable methods.[6] Breslow's[7] version of the Cox proportional hazard model[8] was used to evaluate the relation between characteristics and survival in a univariate and multivariate fashion. A detailed description of our use of this model has been published elsewhere.[9]

Table 1 *Details of study population (335 patients)*

Men	290 (87)
Women	45 (13)
History of hypertension	100 (30)
History of diabetes mellitus	43 (13)
Symptoms	
Asymptomatic	1 (<1)
Stable angina	180 (54)
Progressive angina	92 (27)
Refractory angina	62 (19)
Left ventricular preoperative balloon pumping	20 (6)
Ejection fraction	
≤0·30	25 (7)
0·31–0·50	103 (31)
>0·50	204 (61)
Extent of coronary artery disease	
One-vessel disease	70 (21)
Two-vessel disease	109 (33)
Three-vessel disease	156 (47)
Jeopardy score 2–6	138 (41)
Jeopardy score 8–12	197 (59)
Number of aortocoronary grafts	
One graft	90 (27)
Two grafts	141 (42)
Three grafts	97 (29)
Four grafts	7 (2)

Numbers in parentheses are percentages
*NB. Three patients did not have left ventricular angiograms.

Results

There were six (2%) operative and eight (2%) late deaths in the 335 patients in the study. The average age of the patients was 53 ±8 (SD) years. Table 1 shows the other baseline variables of the study population. None of the variables was related to survival, whether univariate or multivariate analysis was employed. The predicted survival of patients stratified according to left ventricular ejection fraction, number of diseased vessels, and jeopardy score is shown in the Fig. No statistical difference in survival exists between any of the subgroups.

None of the 25 patients whose left ventricular ejection fraction was 0·30 or less died in the perioperative period, and no late deaths occurred in this subgroup until after 36 months of follow-up. Clinical and angiographic information for this subgroup is summarised in Table 2; mean age was 52 ±11 (SD) years. Most patients underwent surgery for the relief of angina. Progressive or refractory angina was present in 60 per cent and 16 per cent of the patients, respectively. Four of the five patients with stable angina were severely limited by effort pain. One patient without angina and one patient with only slight limitation of

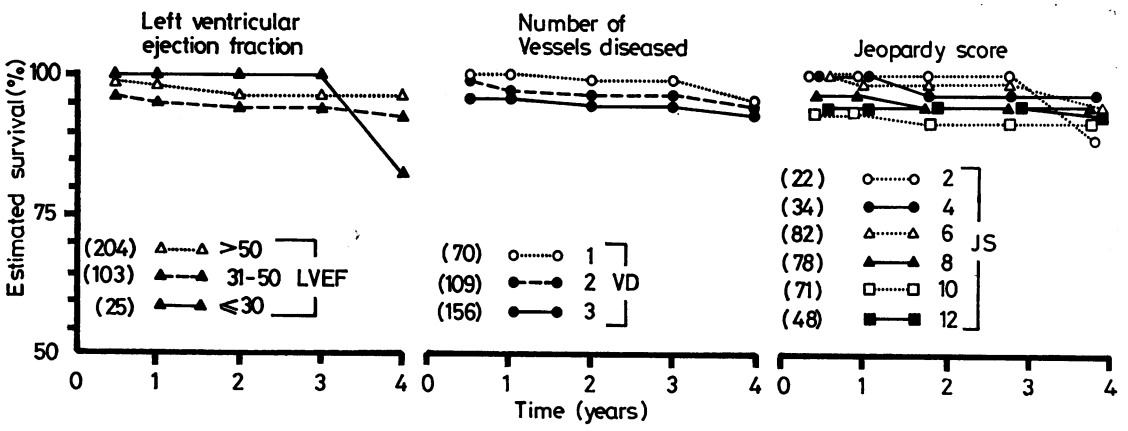

Fig. *Overall life table survival curves of the study population stratified according to left ventricular ejection fraction, the number of diseased vessels, and the jeopardy score. Numbers in parentheses indicate the number of patients in each group who underwent surgery. All patients, except two lost to follow-up, were followed for three years; approximately one-half of the patients were followed for four years. There was no significant difference between the survival of the groups. The mean value and standard deviation for each point on the curves may be obtained from the authors on request.*

physical activity because of angina underwent surgery for ventricular arrhythmias. Though the two late deaths in this group occurred in patients with preoperative heart failure, none of these patients underwent surgery primarily for relief of heart failure. Intra-aortic balloon pumping for control of ischaemia was used preoperatively in six patients.

Discussion

This study was undertaken to analyse variables affecting the survival of patients without stenosis of the left main coronary artery who undergo aortocoronary bypass grafting. In this series of patients operated on between 1974 and 1976, operative mortality was low (2%), and the predicted four-year survival is excellent (94%). As judged at three to four years of follow-up, the preoperative presence or absence of an unstable angina pattern, extensive coronary artery disease, or impaired left ventricular function was unrelated to postoperative survival.

Our finding that aortocoronary bypass grafting does not carry a higher risk in patients with unstable compared with stable angina is consistent with some but not all previously reported studies.[10] Vigorous medical treatment in the immediate preoperative period is possibly responsible for our surgical success with patients who have unstable angina. All of our patients with progressive or refractory angina were treated with the largest tolerated doses of nitrates (including intravenous glyceryl trinitrate on some occasions) and, unless contraindicated by heart failure, propranolol. If these measures were not effective in controlling the patients' symptoms, intra-aortic balloon pumping was instituted. In most cases no attempt was made to wean the patients off propranolol before operation. Though angina could not always be prevented using these measures, almost all patients

Table 2 *Details of 25 patients with a left ventricular ejection fraction of 0·30 or less*

Symptoms	
Asymptomic	1
Stable angina	5
Progressive angina	15
Refractory angina	4
Heart failure	12
Cardiothoracic ratio > 0·50	13
LV end-diastolic pressure > 25 mmHg	9
Indication for operation	
Angina	23
Ventricular arrhythmias	2
Heart failure	0
Intra-aortic balloon pumping	6
LV ejection fraction	
0·0–0·10	0
0·11–0·20	4
0·21–0·30	21
Extent of coronary artery disease	
Three-vessel disease	17
Two-vessel disease	4
One-vessel disease	4
Jeopardy score 2–6	6
Jeopardy score 8–12	19

LV, left ventricular.

experienced improvement, and once stabilised, were able to undergo semi-elective revascularisation surgery later during their stay in hospital.

Our finding that the preoperative extent of coronary artery disease is unrelated to postoperative survival is supported by the study of Hammermeister and co-workers,[11] but others have not agreed, possibly because, unlike us and Hammermeister *et al.*, they have not considered patients with left main coronary artery stenosis separately.[12–14] We believe that the jeopardy score relates the extent of coronary artery disease to the degree of left ventricular damage more precisely than the standard designation of one, two, three-vessel disease. The jeopardy score has proved useful in predicting survival after aneurysmectomy,[15] and has previously been shown to be superior to the number of diseased vessels in predicting susceptibility to the cardiomyopathic syndrome resulting from coronary artery disease.[5] Nevertheless, in the present study neither the jeopardy score nor the standard one, two, three-vessel disease classification predicted postoperative survival. Since the extent of coronary artery disease is a well-established predictor of survival in patients with coronary artery disease before operation,[9 16 17] this suggests that bypass grafting has so improved the coronary circulation that the preoperative extent of coronary artery disease no longer affects prognosis. Hammermeister and co-workers[11] interpreted their results similarly.

The most surprising result of our study is that none of the patients whose preoperative left ventricular ejection fraction was 0·30 or below died in the perioperative period, and their predicted survival at four-year follow-up is 82 per cent. We believe that patient selection is the most likely explanation for this relatively favourable outcome. With only one exception, our patients were operated on because of angina, and angina which showed a progressive or unstable pattern in three-quarters of them. The preoperative left ventricular ejection fraction is probably partly determined by reversible ischaemia in this clinical setting, at least in some patients. This concept accounts for why resting left ventricular wall motion is improved postoperatively in some patients,[18–22] albeit a minority,[23] who undergo revascularisation. Other recent studies of aortocoronary bypass operations in patients with a left ventricular ejection fraction of approximately 0·35 or less, but whose predominant symptom was angina, have shown results similar to ours: perioperative mortality ranging from 0 to 5 per cent and estimated two-year survival ranging from 80 to 100 per cent.[24–27] By contrast, in patients with comparable left ventricular ejection fractions undergoing revascularisation primarily for heart failure rather than angina, perioperative mortality ranged from 15 to 25 per cent, and estimated two-year survival from 50 to 75 per cent.[28–31] Some in this latter group also had mitral valve replacement or aneurysmectomy, but these in themselves cannot account for the relatively low likelihood of survival, since neither procedure is associated with a high mortality in appropriately selected patients with coronary artery disease.[15 32–34]

It is possible that augmented ventriculography will allow us to predict with greater certainty which patients with impaired ventricular function will respond favourably to aortocoronary bypass grafting. Angiographic reassessment of left ventricular wall motion and left ventricular ejection fraction after glyceryl trinitrate, adrenaline, or post-extrasystolic potentiation has disclosed improvement in wall motion in some patients; the left ventricular ejection fraction may rise as much as 0·20.[35–38] Preliminary data have suggested that patients in whom the ejection fraction improves after aortocoronary bypass grafting are more likely to have shown post-extrasystolic potentiation preoperatively than those in whom it does not.[37] Patients in whom augmented ventriculography shows a rise in left ventricular ejection fraction exceeding 0·10 are said to have a low perioperative mortality and a good long-term prognosis, even if their baseline ejection fraction is as low as 0·30.[39]

Preoperative thallium-201 imaging may help distinguish patients in whom reversible ischaemia is responsible for extensive wall motion abnormalities. Such patients should have smaller perfusion defects on initial imaging than would be predicted by the ventriculogram and have perfusion defects that partially or completely "fill-in" on delayed imaging.[40 41] Nevertheless, the predictive value of preoperative thallium imaging remains to be determined, and we believe that the present study indicates that patients with severely impaired left ventricular wall motion should not be refused aortocoronary bypass grafting if symptoms of angina pectoris are severe and predominate over symptoms of heart failure.

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